China Energy Group

Sustainable Growth Through Energy Efficiency

Berkeley Lab

Ernest Orlando Lawrence
Berkeley National Laboratory

China Energy Group

**China is fueling its phenomenal economic growth with huge quantities of coal.
The environmental consequences reach far beyond its borders—
China is second only to the United States in greenhouse gas emissions.**

**Expanding its supply of other energy sources, like nuclear power
and imported oil, raises trade and security issues.
Soaring electricity demand necessitates the construction of 40–70 GW
of new capacity per year, creating sustained financing challenges.**

**While daunting, the challenge of meeting China's energy needs presents
a wealth of opportunities, particularly in meeting demand
through improved energy efficiency and other clean energy technologies.**

**The China Energy Group at the Lawrence Berkeley National Laboratory (LBNL)
is committed to understanding these opportunities, and
to exploring their implications for policy and business.
We work collaboratively with energy researchers, suppliers, regulators,
and consumers in China and elsewhere to:**

better understand the dynamics of energy use in China

**develop and enhance the capabilities of Chinese institutions
that promote energy efficiency**

create links between Chinese and international institutions

BERKELEY LAB

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

Research

Our Research Focus Encompasses Three Major Areas: Buildings, Industry, and Cross-Cutting Activities.

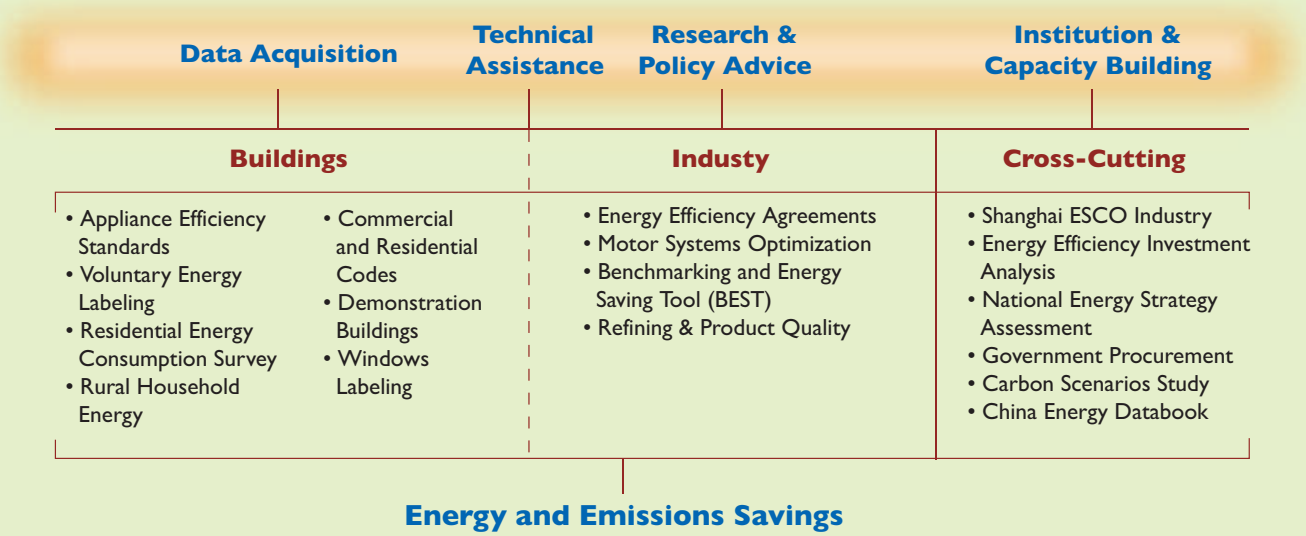
1 **Buildings**—working to promote energy-efficient buildings and energy-efficient equipment used in buildings. Current work includes promoting the design and use of minimum energy efficiency standards and energy labeling for appliances, and assisting in the development and implementation of building codes for energy-efficient residential and commercial/public buildings. Past work has included a China Residential Energy Consumption Survey and a study of the health impacts of rural household energy use.

2 **Industry**—understanding China's industrial sector, responsible for the majority of energy consumption in China. Current work includes benchmarking China's major energy-consuming industries to world best practices, examining energy efficiency trends in China's steel and cement industries, implementing voluntary energy efficiency agreements in various industries, and developing a multi-year program for standards and for optimizing the industrial motor systems in China. Past work has included a comprehensive study of China's oil refining sector.

3 **Cross-Cutting**—analysis and research focused on multi-sector, policy, and long-term development issues. Current cross-cutting policy and analysis research includes work on investment in energy infrastructure and energy efficiency; government procurement programs; energy service companies; a national energy policy assessment including the National Energy Strategy released by the government in early 2005; energy efficiency policy; an analysis of past trends in energy consumption in China as well as of future scenarios; and our China Energy Databook accompanied by chapter summaries and analysis of recent trends.

All research activities involve extensive collaboration and capacity building—developing organizations to promote energy efficiency in China, and providing targeted training for our Chinese colleagues. We have been instrumental in establishing important new institutions to deal with China's energy problems; the China Sustainable Energy Program (funded by the Packard and Hewlitt Foundations and managed by the Energy Foundation) and the Beijing Energy Efficiency Center are two prominent examples.

Through its current activities, LBNL's China Energy Group continues to provide a unique service, applying international experience to facilitate the adaptation and deployment in China of key energy efficiency policies and technologies.



Major Ongoing Activities

工业

Appliance Standards and Labeling

In the area of energy consuming equipment, our appliance standards and labeling programs are among the most active. Why do we have such a focus?

The Energy Conservation Law of 1997 mandated the development of energy efficiency standards; a major driver behind the emphasis on this activity was the dramatic growth in appliance and other equipment saturation in the Chinese market.

The graph below shows only the major household appliances in Chinese urban areas—a market of about 500 million people. The graph omits popular consumer electronics such as VCDs, DVDs, and stereos, but a similar growth trend could be seen for these products and for other office equipment. Markets for these products have grown from zero to near-maturity in the space of about 20 years. Rural markets of 800 million people are about 10–15 years behind the urban markets.

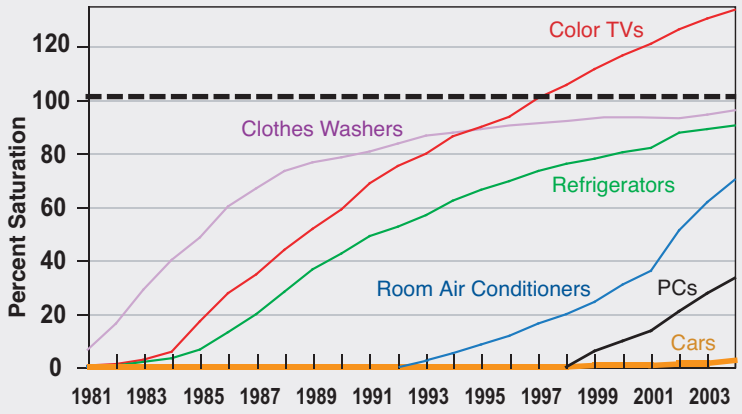
With such a large and growing market for appliance ownership, early intervention in the form of minimum energy efficiency standards and labels promises to deliver significant energy savings. Our work began in 1996 while the market for these products was growing rapidly.

China is a Major Global Producer

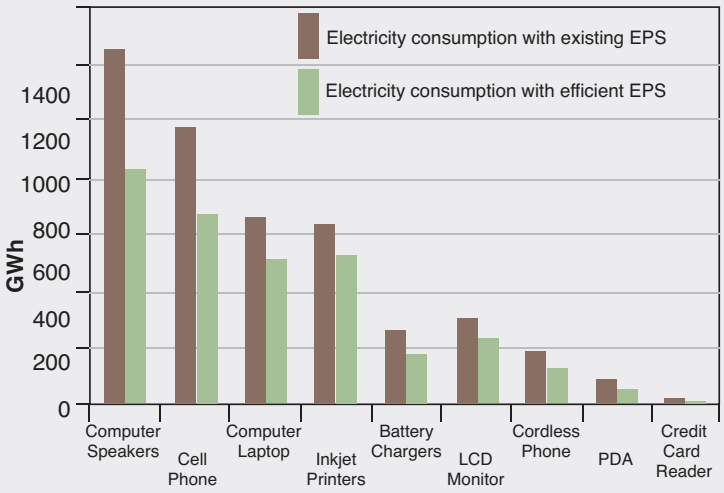
From another angle, China is also one of the largest global producers of major appliances and consumer electronics, and for some products provides over 50% of the global supply. By 2005, these production numbers had grown to over 20 million refrigerators, over 60 million air conditioners, and 80 million color TVs. To the extent that our work increases the efficiency of Chinese-produced appliances, the global market benefits as well.

In short, appliance efficiency programs and China make a great combination. For example, efficient power supplies in 12 major end-uses would reduce consumption by 1.23 TWh, at a savings of $86 million in consumer electricity charges.

Urban Ownership of Major Appliances



Potential Savings from Efficient Power Suplies in China



1988
Organized and participated in major China-U.S. conference on energy demand, markets, and policy. Nanjing.

1989
Created exchange program with Energy Research Institute.

1990
Produced first-ever assessment of China's energy conservation outside of China—revealing remarkable achievements in efficiency.

建筑

Building Energy Efficiency

In addition to building equipment standards and labeling, we have also had a long-standing program to assist China in developing building energy codes. China faces the same complexity as the US in having a number of distinct climate zones. Historically, concern has only been on codes within the heating zone, although this focus is expanding.

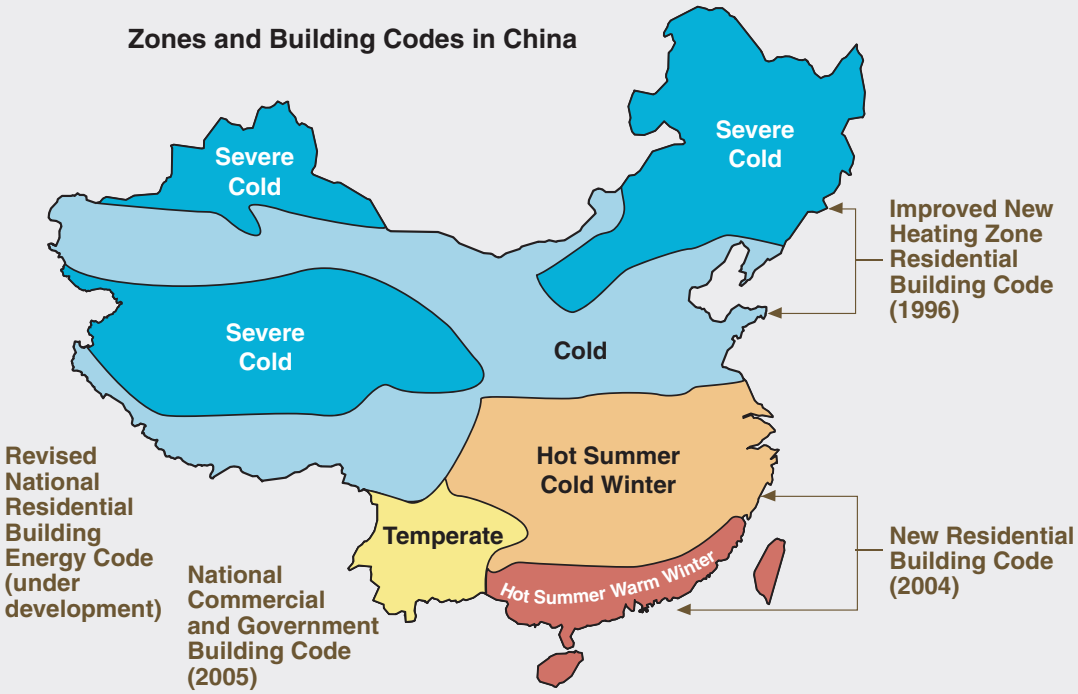
Objectives of China's building energy codes are at least 50% energy savings at less than a 10% cost increase compared to pre-existing buildings. Increasing technical sophistication and flexibility allow for a shift from steady-state calculations to computer simulations, and from rigid requirements to a choice of simple prescriptive and custom energy budget methods. Building codes in China are developed by Code Compilation Committees with increasing industry involvement. They undergo public review and approval, before adoption by the Ministry of Construction.

Our work with China has involved training in DOE-2 and other building energy simulation software, transfer of software, and assistance in the drafting and implementation of China's building energy standards. The first residential code was for the Heating Zone in 1996. We participated in the development of residential energy standards for the Hot Summer Cold Winter region (2001) and the Hot Summer Warm Winter region (2004). We have also supported pilot efforts in Shanghai and four cities in South China to implement building energy codes.

Recently we also worked with China to develop a pilot windows rating and labeling program, drawn from the U.S. National Fenestration Rating Council. This was started in the southern city of Guangzhou.

National Building Energy Design Standard for Public Buildings

LBNL participated in the development of the first national building energy standard (previous ones were industry standards) for public buildings, which are roughly analogous to what are called commercial buildings in the US. The objective of the standard is to reduce total building energy use by 50%. Prescriptive requirements are linked to custom budgets for building envelope requirements. HVAC requirements utilizes the 2004 Chiller Rating System. Lighting requirements are covered by 2003 Lighting Standard.



1991

Completed initial studies on 3 industries—iron & steel, building materials, and chemicals—revealing large energy efficiency opportunities.

1992

Published first edition of the China Energy Databook, acknowledged to be most authoritative sourcebook of its kind. (Five major revisions through 2004.)

1993

With collaborators (PNNL) founded the Beijing Energy Efficiency Center (BECon).

综合

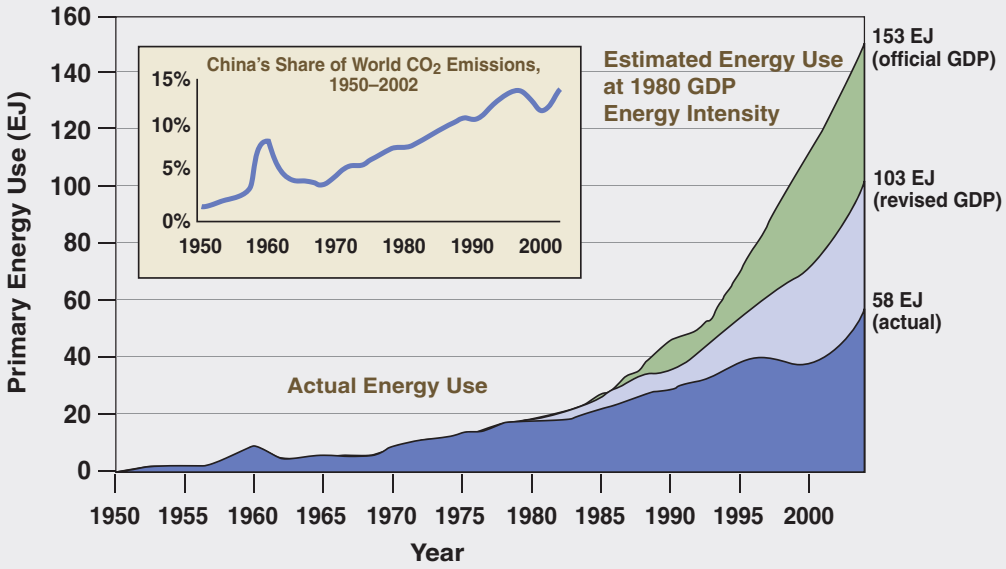
Cross-Cutting Policy and Analysis

The China Energy Group is a leader in analyzing Chinese energy policy. We released the first studies outside China on its extensive programs to promote energy efficiency, showing a well funded program of investments in cost-effective energy-efficiency projects. This and other programs were crucial to decoupling economic and energy growth in China—a remarkable achievement for an industrializing country.

Ironically, economic reform of the mid to late 1990s has swept away much of the apparatus developed in the 1980s—including market-based incentives. China is reintroducing market-based incentives, and took a major step forward in establishing a legal basis for energy-efficiency work with the passage of the Energy Conservation Law in November 1997. We have prepared a report on developments in energy-efficiency regulations and programs since 1997.

Why the Focus on China?

China is the second largest energy consumer in the world after the US. Of actual energy consumption shown here, 66% is coal, 23% is oil, 8% is hydropower, 3% is natural gas.



When we first began working in China 18 years ago, it was not yet a major player in the world energy, industrial, trade, and economic scene. It had just emerged from 30 years of isolation from many other countries and was reorienting its development goal to rapid modernization. Isolated from the world economy, China priced energy extremely low and used it wastefully. As evident from the chart, if the intensity of energy use in 1980 had not changed, while GDP had grown at the same rate in the last 25 years, China would already be consuming 50% more energy than the US and be the largest energy consumer and CO_2 emitter in the world.

The difference between what might have happened and what actually happened is the result of a strong focus on energy efficiency. China has again set ambitious goals for economic growth and for restraining growth of energy demand. However, in the early years of the 21st century, energy intensity has increased for the first time since before 1980. Our current work is emphasizing ways to cut demand growth. Our current cross-cutting policy and analysis research includes work on investment in energy infrastructure and energy efficiency; government procurement programs; energy service companies; national energy and energy efficiency; policy assessment; analysis of past trends in energy demand in China and future scenarios; and our China Energy Databook accompanied by analysis of recent trends.

Energy Policy Assessment

The China Energy Group was the first group outside China to release studies on China's extensive programs to

1995

Published major analysis of causes of reduced energy intensity in Chinese industry.

Assumed leadership of EPA project to transform market to produce energy-efficient CFC-free refrigerator in China.

Participated in Presidential Mission on Sustainable Development and Trade to China; led the Energy Policy Team, China-U.S. Energy Efficiency Working Group.

promote energy efficiency, showing a well-funded program of investments in cost-effective energy-efficiency projects. This and other programs were crucial to decoupling economic and energy growth in China—a remarkable achievement for an industrializing country.

National Energy Strategy Report

China aims to quadruple GDP from 2000 to 2020 while only doubling energy use—a challenge to energy security, social welfare, and environmental imperatives. At the same time, the country seeks to shift towards cleaner fuels in all sectors. Yet, over the past several years, energy use has been rising faster than GDP. Dependence on coal shows no sign of diminishing. Imports of oil and gas are expected to rise for many years. The Energy Foundation's China Sustainable Energy Program commissioned the Development Research Council of China's State Council to lead a major study on energy strategy and policy for China.

LBNL Assessment

The China Group has completed an assessment outlining additional issues in design and implementation of a comprehensive energy strategy. The goal of this assessment has been to help the Chinese government connect high level policy goals—energy security, economic growth, equity, etc.—with changes in energy investment, supply, and efficiency.

Industrial Energy Efficiency

We have been working with industrial sector experts in China for several years to explore options for industrial energy efficiency policies, providing information on programs that are effective in other countries and that may be suitable for the increasingly market-based industrial sector in China.

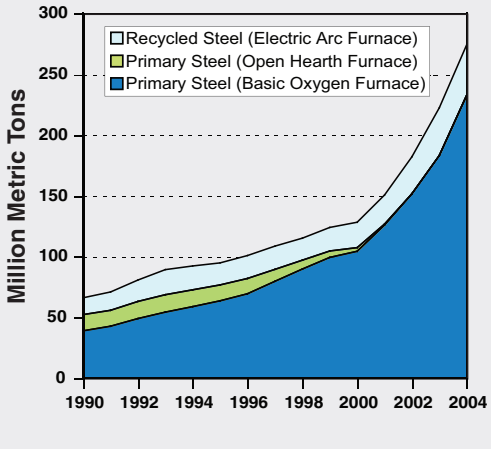
Iron and Steel Pilot Project

Chinese experts chose to test Voluntary Energy Efficiency Agreements as a new policy mechanism through a pilot project with two iron and steel mills in Shandong province. LBNL provided extensive background information and training related to how such agreements have been designed and implemented in developed countries around the world. The LBNL team developed a Benchmarking and Energy Saving Tool (BEST) to benchmark the two plants to world best practice and to identify energy efficiency improvement opportunities. On this basis, the pilot plants agreed to an energy efficiency target for 2005, and the province responded with technical assistance, financing arrangements, and public recognition.

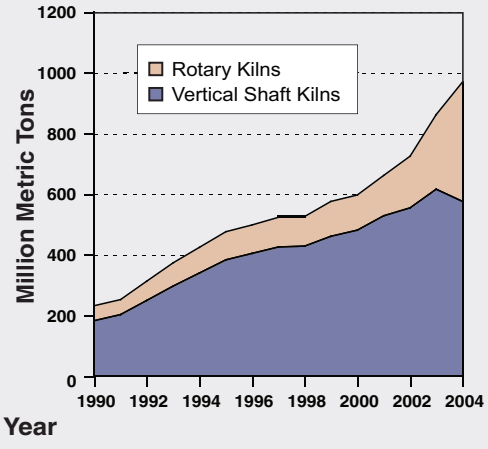
The Voluntary Energy Efficiency Agreements were signed with two major steel mills in Shandong: Jigang and Laigang. Both were already better than the China average, which varies widely because of the mix of small and large plants in many dispersed locations. A recent performance review showed that both plants were well on their way to achieving their agreed-upon targets.

The experience in this pilot laid the foundation for the expansion of this approach to the iron and steel sector and to a number of other industrial sectors. This activity has been supported by the End Use Energy Efficiency Program (EUEEP) through the Global Environmental Facility, as well as through China's Top 1000 Energy-Consuming Enterprises Program.

China's Crude Steel Production 1990-2004



China's Cement Production 1990-2004



Year

1996
Promoted investment in cogeneration by co-sponsoring workshops and producing market assessment of cogeneration in China.

1997
Initiated major appliance standards training program.

1998
Developed $48M project with the Global Environmental Facility to upgrade efficiency of Chinese refrigerators.

Motor Systems

Motor-driven industrial systems consume huge amounts of energy: about 2200 billion kWh annually on a global basis. In the U.S., motors are 65% of industrial electrical consumption or 550 billion kWh. For pumping systems worldwide, motor systems contribute 20% of the total electrical energy demand. These systems (motor/drive, fan, pumping, and compressed air) are present across all industrial sectors and represent a major energy savings opportunity, typically 20% or more.

Chinese factories, particularly in the coastal cities and enterprise zones, have been growing very rapidly (up to 100% annually) to meet both domestic and export demand. By 2004, many of these factories were experiencing both caps on and interruptions to electrical supply which constrained growth and resulted in involuntary work stoppages. By optimizing industrial motor systems, Chinese factories can more effectively apply the available electrical supply to support production.

Intensive training was provided to Chinese experts in blocks of 1 to 1–1/2 weeks over the course of 18 months. Training included both classroom and hands-on training in factories. LBNL's role was to develop the program design, form and lead a team of international system optimization experts, provide ongoing technical assistance and project development support to the Chinese experts, and draft the system efficiency standards.

The first 38 plant assessments conducted by Chinese experts identified nearly 40 million kWh in annual energy savings, with an average per system energy savings of 23%.

Under the EUEEP, Chinese experts will co-train with international experts to bring system optimization techniques to more engineers in 2–3 additional provinces, with two experts receiving additional traning in U.S.

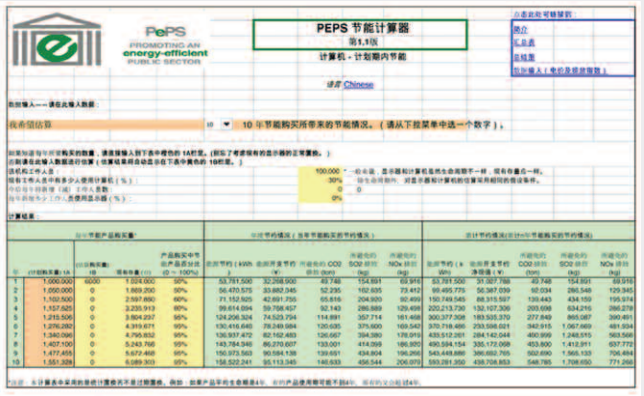
Government Procurement

Promoting an Energy-efficient Public Sector (PePS) is a collaborative effort of LBNL and other U.S. non-profits to promote and assist energy conservation programs in governments around the world. PePS draws on the experience of the U.S. DOE Federal Energy Management Program and other successful national programs as models. In 2003, China's premier called for accelerated efforts to improve the energy management of China's government. LBNL/PePS joined with the China Standard Certification Center to provide technical assistance in establishing China's first energy-efficiency government procurement program.

Between 1990 and 2002, public sector electricity demand grew at a 11.2% average annual rate compared to 8.3% for the whole economy. Public sector electricity consumption nearly equals that of all 800 million Chinese rural residents and accounts for 5% of the national total. Public sector energy spending hit ¥80 billion (~$10 billion) in 2000. A 2002/2003 survey of public buildings found a 23% technical potential for savings in existing equipment.

To date, we have assisted in providing international examples of policies and regulations, surveying existing energy use patterns in public sector buildings, developing a methodology for product selection in China, and developing a tool to estimate potential savings. A Chinese policy was announced on 17 December 2004, modeled after the US Federal Energy Management Program, with implementation that began in 2005. The first round of products covered include refrigerators, room AC, computers, printers, televisions, double-capped fluorescents, compact fluorescent lights, toilets and faucets.

Chinese Version of Energy Savings Tool



1999

Actively participated with Packard Foundation to create the China Substainable Energy Program at the Energy Foundation.

2000

Technical advice to large-scale buildings energy standards programs.

2001

Created the Shanghai Pacific Energy Center with Chinese collaborators.

Initiated multi-year program of training in motor systems energy conservation.

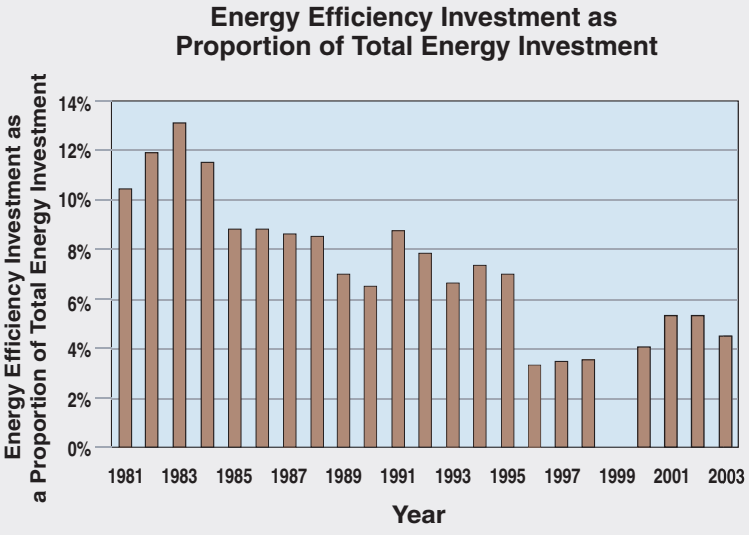
Future initiatives include the development of informational and educational materials for each product category subject to the procurement, the addition of new products to procurement list, and the formulation of new government energy management policies and programs.

Energy Investment

The long-standing government policy on energy gives equal role to both development of energy supply and to efficiency, and places greater emphasis on efficiency. However, in 2002, investment in energy supply was 28 times greater than investment in efficiency!

This disparity is seen as the continuation of a trend that became particularly pronounced after 1996. As a percent of energy supply investment, energy efficiency investment fell from a high of 13% in 1982 to a low of about 3.5% in 1996, with only a slight rebound since then.

So how much investment is needed to make a difference? We calculate that about $25 billion a year invested in energy efficiency would turn the current trend around, assuming a long-term energy demand growth rate of 7% and a target of shaving annual energy demand growth to 3.5%. Of course, these are just rough calculations, but the key comparison to make is with current spending, which is only about $3 billion per year.



China Energy Databook

Reliable and accurate data are critical to good analysis for policy and business. In 1992, we released the first edition of the China Energy Databook, acknowledged to be the most comprehensive and authoritative sourcebook of its kind. We continue to collaborate with Chinese researchers, and several revised and expanded editions have been released.

We have now completed the China Energy Databook v. 6.0, a comprehensive electronic version. The Databook consists of two products. The first is a fully relational database of national and provincial energy balances, plus detailed sectoral energy end-use tables, developed in Microsoft Access 2000, and containing over 103,000 data points. The second is a set of several hundred tables and figures in Microsoft Excel and PDF formats, organized into ten chapters, including extracts from the database and standalone spreadsheets containing data that cannot be treated on a relational basis. The data series cover available information from 1949. Many are updated through 2002 or, where possible, 2003.

2002

Assisted China to design and implement government energy-efficiency procurement program.

2003

Provided technical assistance for Shanghai's commercial building codes.

2004

Assisted pilot implementation of voluntary energy efficiency agreements in Shandong Iron and Steel Industry.

Institution and Capacity Building

The success of our work in China relies heavily on cooperation with a wide range of organizations and groups, each of which bring something different to the table. Our funding support, for example, has long been a mix of US government and private foundation sources. In China, we primarily work with government offices or research centers on efficiency projects that in turn are provided to the central government for approval and implementation. At the same time, our research and analysis directly informs US government agencies and has supported bilateral US-China energy agreements such as those implemented through DOE. Our research teams often involve experts from other departments or divisions of the lab, other laboratories, academic institutions, NGOs, and international organizations such as UNDP, GEF, and others.

A large component of our activities is training of our Chinese counterparts, and much of it happens at LBNL. In the last 9 years, we've recorded 246 person-weeks in training of 145 Chinese personnel at LBNL, not to mention the 228 person-weeks of training inside China, primarily for the motors systems optimization work. In addition to training, the time spent at LBNL has also helped us create close ties with our counterparts. It improves their understanding of the overall working of LBNL and efficiency work in the US, and opens the door to further work in China.

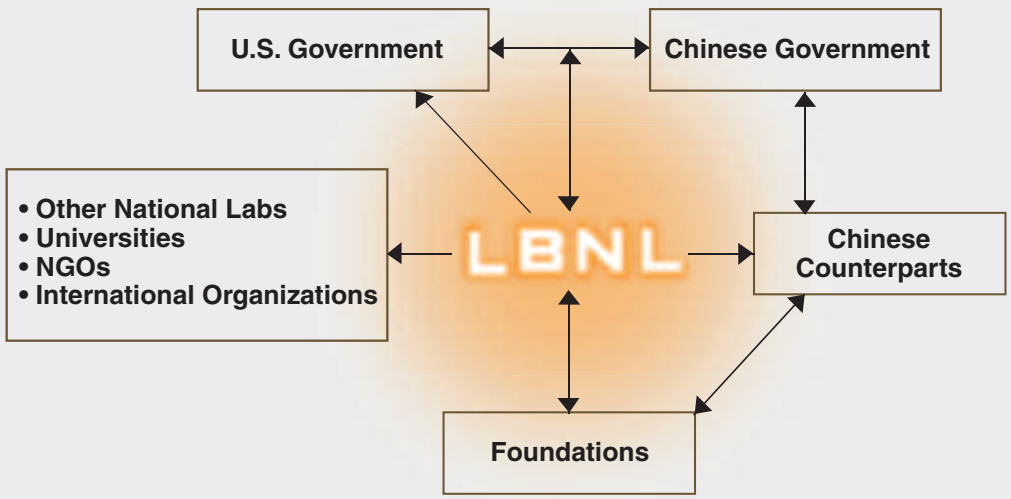
In 1993, LBNL helped China to establish a vital new organization to promote energy efficiency: the Beijing Energy Efficiency Center (BECon). BECon links China and the outside world, providing energy consulting and marketing services to businesses and others. BECon has helped initiate China's Green Lights Program—which promotes the manufacture and use of efficient lights. It has also managed a GEF project to build a commercial energy-efficiency industry in China.

.

Extensive Training Programs Over Last 9 Years

Training at LBNL	Number of Personnel Trained	Total Training (person-wks)	Training in China (person-wks)
Standards & Labeling	31	138	228
Buildings	41	14	
Industry	43	66	
Scenarios	30	28	

Mode of Collaboration



2005

Collaborated with BECon to create full end-use model of China's energy economy for 2020.

2006

Assessed ways for China to meet its goal of reducing energy intensity by 20% in five years.

China Energy Group Staff

Energy Policy Assessment, Institution and Capacity Building

Mark Levine, China Group Leader (Founder) and Director, Environmental Energy Technologies Division. MDLevine@lbl.gov

Appliance Standards and Labeling, Government Procurement, Databook

David Fridley, Deputy Group Leader. DGFridley@lbl.gov

Appliance Standards and Labeling, Energy Investment

Jiang Lin, Scientist. J_Lin@lbl.gov

Policy Assessment, Industrial Energy Efficiency, Databook

Jonathan Sinton, Scientist. JESinton@lbl.gov

Energy Policy Assessment

Nan Zhou, Post Doctoral Fellow. NZhou@lbl.gov

Industrial Energy Efficiency, Energy Policy Assessment

Nathaniel Aden, Senior Research Associate. NTAden@lbl.gov

Building Energy Efficiency

Joe Huang, Staff Scientist, Building Technologies Department. YJHuang@lbl.gov

Industrial Energy Efficiency

Lynn Price, Deputy Group Leader, International Energy Studies. LKPrice@lbl.gov

Industrial Energy Efficiency, Motor Systems

Aimee T. McKane, Program Manager. ATMcKane@lbl.gov

Funders

Initial funding for the China Energy Group was provided by the U.S. Department of Energy (DOE/ Environmental Policy Office). After several years, the U.S. Environmental Protection Agency (EPA/Global Change Division) joined DOE as a funder. More recently, the Energy Foundation (China Sustainable Energy Program) became major source of funds. Other valuable sources of funds were the Shell Foundation, Blue Moon Fund, the UN Foundation, and UNDP. The staff of the LBNL China Energy Group is deeply grateful to individuals from these and other organizations who have provided support over these many years.

Visit us online for more information and our latest projects:

http://china.lbl.gov

Collaborators In China

Beijing Development and Reform Commission (BDRC)

Beijing Energy Efficiency Center (BECon)

Beijing Science and Technology Commission

Beijing Sustainable Development Center (BSDC)

Beijing University

China Academy of Building Research (CABR)

China Academy of Social Sciences (CASS)

China Administration of Quality, Supervision, Inspection and Quarantine (AQSIQ)

China Cement Association

China Energy Conservation Association (CECA)

China Energy Conservation Investment Corporation (CECIC)

China Household Electrical Appliances Research Institute (CHEARI)

China Iron and Steel Association (CISA)

China National Institute of Standardization (CNIS)

China National Offshore Oil Corporation (CNOOC)

China National Petrochemical Corporation (Sinopec)

China National Petroleum Corporation (CNPC)

China Standards Certification Center (CSC)

College of Environmental Sciences, Beijing (Peking) University

Development Research Center (DRC)

Energy Research Institute (ERI)

Guangdong Provincial Institute of Building Research

Institute of Nuclear Energy Technology (INET)

Institute of Technical Information for the Building Materials Industry of China

Leading Group on Climate Change

Ministry of Construction Energy Efficiency Bureau

Ministry of Construction Research Institute of Standards and Norms (RISN)

Ministry of Finance Research Institute for Fiscal Science (RIFS)

Ministry of Foreign Affairs

Ministry of Science and Technology (MOST)

Nanjing/Jiangsu Energy Conservation Center

National Building Energy Efficiency Commission

National Bureau of Statistics (NBS)

National Development and Reform Commission (NDRC)

Shanghai Construction Commission

Shanghai Economic Commission

Shanghai Energy Conservation Service Center

Shanghai Energy Conservation Supervision Center

Shanghai Pacific Energy Center

State Environmental Protection Administration (SEPA)

State Power Economic Research Center

Tsinghua University

China Energy Group

ENVIRONMENTAL ENERGY TECHNOLOGIES DIVISION

ERNEST ORLANDO LAWRENCE
BERKELEY NATIONAL LABORATORY

BERKELEY LAB

Ernest Orlando Lawrence Berkeley National Laboratory is a multi program national laboratory managed by the University of California for the U.S. Department of Energy.
This work was supported by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098.

LBNL/PUB-796 (2006)